SGIP 2014-15 Impact Evaluation

Impacts, Data Issues and Recommendations

December 12, 2016

TOPICS

- Overall goals, objectives and scope of the evaluation
- Renewable fuel use verification
- SGIP customer load data
- Advanced energy storage
- Questions and Answers

OVERVIEW

- Overall goal of the 2014-15 SGIP impact evaluation
  - Expected versus observed impacts (peak demand, GHG and criteria air pollutant emission reductions, renewable fuel use, energy savings)
- Objectives
  - Transparency in approach and methodology
  - Reproducible results based on project level data
  - Actionable recommendations
- Scope
  - Impacts of the SGIP during 2014-15 using available data and agreed upon methodology
- Focus today is primarily on data issues encountered and how to address these moving forward

RENEWABLE FUEL USE VERIFICATION

Data Issues and Recommendations

OVERVIEW

» Regulatory Requirements

» Analytic Approach
  - On-Site Biogas Verification
  - Directed Biogas Verification

» Data Issues

» Conclusions and Recommendations

REGULATORY REQUIREMENTS

Genesis of the Renewable Fuel Use Reports

- CPUC Decision 02-09-051 (September 19, 2002)
  - Established increased incentives for renewable projects
  - Created renewable fuel use report to:
    - Verify compliance with minimum renewable fuel use requirements (prevent fuel switching)
    - Provide information on renewable project costs (in support of program design)
    - Must be filed every six months
- CPUC Rulemaking 12-11-005 (November 8, 2012)
  - Decreased reporting frequency from semi-annual to annual

COMPLIANCE OVERVIEW

Biogas Projects

- Received a renewable incentive

Dedicated On-Site Biogas

- Site visit

Blended On-Site Biogas

- Compliance determined based on metered data

Directed Biogas

- Compliance determined based on invoices and other documents

HISTORY OF RFU COMPLIANCE

Blended On-Site Biogas Projects

SGIP Reservation No.	Type	Size (kW)	Digester Input	Payment Date	RFU Report No.																
					8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SCE-SGIP-2003-0092	FC	500	WWTP	11-Mar-05	??	Yes	??	Yes	Yes	No	Yes	Yes									
SCE-SGIP-2003-0017	ICE	500	WWTP	11-May-05		Yes	Yes	Yes													
SCE-SGIP-2004-0158	ICE	704	WWTP	25-Oct-06				??	??	??	??										
SCE-SGIP-2004-0159	ICE	704	WWTP	26-Oct-06				??	??	??	??										
PGE-SGIP-2005-1313	MT	240	WWTP	06-Mar-07					Yes	Yes	Yes	Yes									
SCE-SGIP-2006-0062	FC	900	WWTP	04-Mar-08							Yes	Yes	No	No	Yes	No	Yes	No			
PGE-SGIP-2006-1490	FC	600	WWTP	24-Apr-08							Yes	Yes	No	No	No	Yes	Yes	Yes			
SCG-SGIP-2006-0036	FC	1,200	WWTP	27-Oct-08								No	No	No	No	No	Yes	Yes	Yes		
PGE-SGIP-2007-1749	ICE	130	WWTP	09-Nov-09										Yes	Yes	Yes	Yes				
SCG-SGIP-2008-0003	FC	600	Food	14-Dec-09										No	No	No	No	No	No	No	
SCG-SGIP-2006-0012	FC	900	WWTP	18-Dec-09										No	No	No	No	Yes	No	Yes	
SD-SGIP-2007-0351	ICE	560	WWTP	16-Apr-10											Yes	Yes	Yes	Yes			
SCE-SGIP-2010-0334	FC	250	WWTP	31-Oct-10												??	??	??	??	??	??
SCE-SGIP-2010-0002	FC	500	WWTP	31-Oct-10												No	No	No	Yes	Yes	??
SCE-SGIP-2009-0003	FC	300	WWTP	30-Aug-11														No	No	No	??
SD-SGIP-2009-0362	FC	300	WWTP	21-Dec-11														No	Yes	Yes	??
SCE-SGIP-2009-0013	FC	600	WWTP	28-Mar-12															No	No	No
PGE-SGIP-2010-1867	FC	1,400	WWTP	29-Nov-12																Yes	No
SCG-SGIP-2010-0026	FC	2,800	WWTP	21-Dec-12																No	No
PGE-SGIP-2012-2061	ICE	3,800	WWTP	31-Oct-13																	??
SCE-SGIP-2011-0348	ICE	650	WWTP	18-Jun-14																	

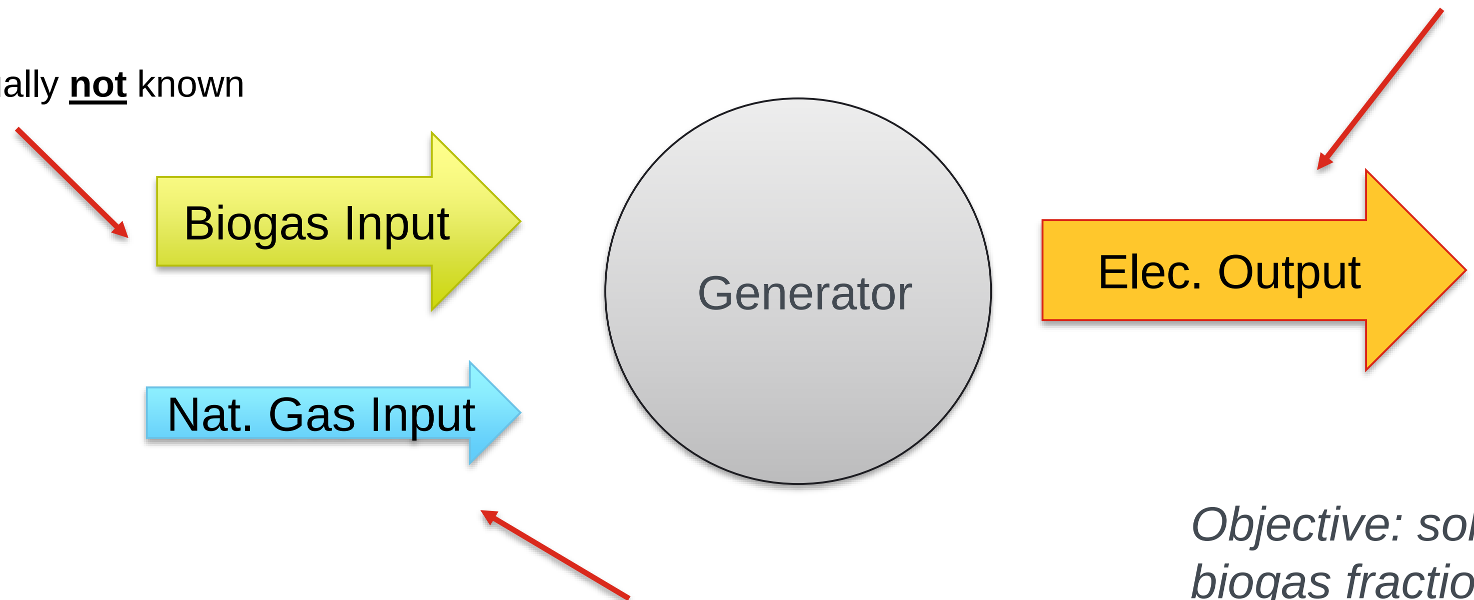
MOTIVATION

Why is Itron occasionally unable to make compliance determinations for on-site or directed biogas projects?

BLENDED ON-SITE BIOGAS

Overview

Biogas input must be at least 75% of total energy input.



Objective: solve for biogas fraction of total fuel input

BLENDED ON-SITE BIOGAS

Compliance Approach

Most often, natural gas input and electric output are known…

$$\text{Elec. Efficiency} = \frac{\text{Elec. Output}}{\text{Biogas Input} + \text{Nat. Gas Input}}$$

Known

$$\text{Biogas Input} = \frac{\text{Elec. Output}}{\text{Elec. Efficiency}} - \text{Nat. Gas Input}$$

Known

Assumed (Low)

BLENDED ON-SITE BIOGAS

Key Issues

» Assuming a low electrical efficiency results in an optimistic compliance determination rather than a specific biogas usage
  - As the SGIP moves towards an incentive mechanism that hinges on achieving specific biogas percentages, this approach will no longer suffice
  - Metered natural gas and renewable biogas consumption data are necessary to quantify specific biogas usage targets

» Historical instances where compliance cannot be determined are due to more than one data stream (electricity, natural gas, or biogas) being missing

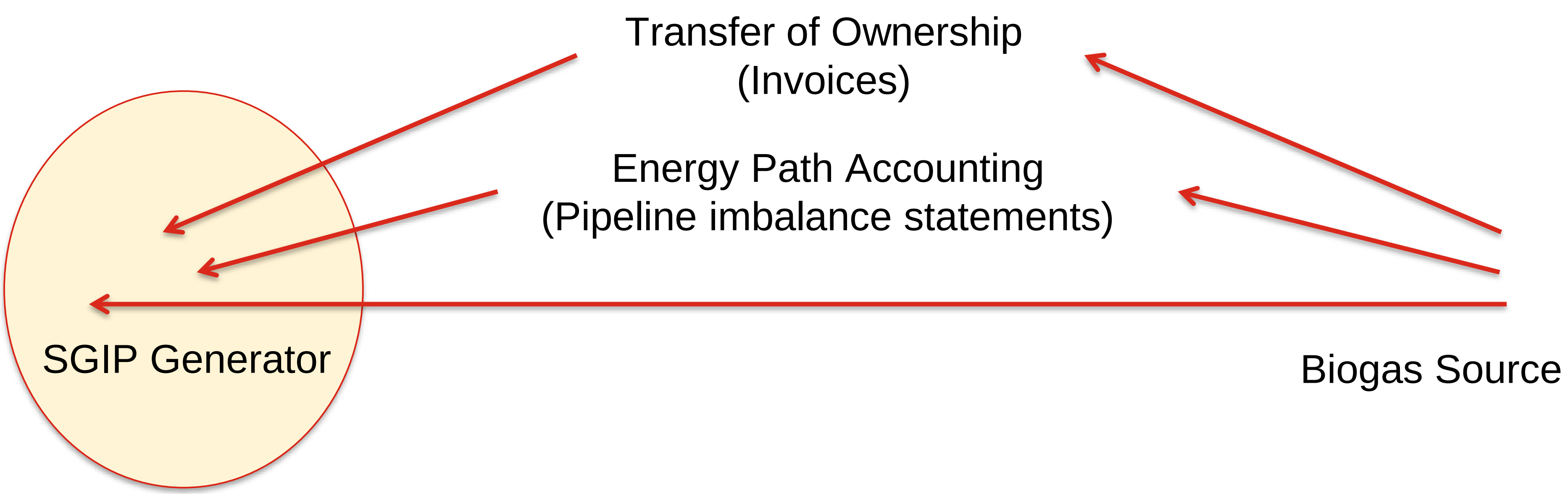
» New program rules are expected to alleviate these data issues

DIRECTED BIOGAS

Overview

» Based on AESC's directed biogas audit protocols (11/23/2011)
- Requires review of documentation such as invoices, pipeline imbalance statements, and other utility documents to determine renewable fuel use

Biogas Pool Tracking



DIRECTED BIOGAS

Key Issues

- Directed biogas compliance determinations fail for one of two reasons:
  - Data and documentation are not provided in a timely manner to the evaluation contractor or auditor, or
  - The data and documentation provided are unclear or not legible

REPORT ID: MNTHDAY REC_STN_EX.SQR

DOMINION TRANSMISSION,
RECEIPT STATION MONTHLY VOL BY DAY
ATMOS ENERGY MARKETING, LLC
MONTH-TO-DATE THRU: 12/31/2010

RUN DATE: 01/06/
RUN TIME: 11:38
PAGE NUMBER: 5

RECEIPT STATION NAME	STATN NUMBR	CUSTOMER	CONTRACT NUMBER	ACTIVITY NUMBER	PRODUCTION DATE	SCHEDULED RECEIPT DTS	SCHEDULED DELIVERY DTS	DELIVERY STATION NM	UPSTREAM CONTRACT	DWNSTREAM CONTRACT
EQUITABLE - PRATT FA	41001	ATMOS ENERGY MARKETI	5B4230	000001	12/29/2010	649	631	TXG - LEBANON	491	21789
			5B4230	000001	12/30/2010	649	631	TXG - LEBANON	491	21789
			5B4230	000001	12/31/2010	592	575	TXG - LEBANON	491	21789
			TOTAL FOR 5B4230 / 000001			13,475	13,092	(1) Green		
			E00251	000078	12/02/2010	402	391	TXG - LEBANON	491	21789
			E00251	000078	12/03/2010	592	575	TXG - LEBANON	491	21789
			E00251	000078	12/04/2010	592	575	TXG - LEBANON	491	21789
			E00251	000078	12/05/2010	592	575	TXG - LEBANON	491	21789
			E00251	000078	12/06/2010	492	478	TXG - LEBANON	491	21789
			E00251	000078	12/07/2010	592	575	TXG - LEBANON	491	21789
			E00251	000078	12/08/2010	634	616	TXG - LEBANON	491	21789
			E00251	000078	12/09/2010	634	616	TXG - LEBANON	491	21789
			E00251	000078	12/10/2010	634	616	TXG - LEBANON	491	21789
			TOTAL FOR E00251 / 000078			5,164	5,017	(2) Green		
			MCS222	000033	12/06/2010	100	100	DTI LOAN POINT - SOU	491	MCS222
			MCS222	000033	12/10/2010	200	200	DTI LOAN POINT - SOU	491	MCS222
			TOTAL FOR MCS222 / 000033			300	300	(3) Parked on Dom Green		
			TOTAL FOR ATMOS MARKETING			18,939	18,409	300 Parked; 18,109 Delivered		
			TOTAL FOR EQUITABLE - PRATT FARM			18,939	18,409			
[redacted]			5B4218	000001	12/01/2010	444	431	[redacted]		
			5B4218	000001	12/02/2010	444	431	[redacted]		
			5B4218	000001	12/03/2010	444	431	[redacted]		
			5B4218	000001	12/04/2010	444	431	[redacted]		

13,092 (1)
5,017 (2)
18,109 Del to TGT @ Lebanon

CONCLUSIONS AND RECOMMENDATIONS

Future Program Design

- Metered natural gas and biogas consumption data must be made available from all blended biogas projects
  - The data must be available in a timely manner in order for findings to be included in future Renewable Fuel Use Reports
- Directed biogas documentation must be provided in a prescribed, timely and legible manner to the Program Administrators
  - Clear protocols must be established that describe acceptable types of documentation and their format
  - We recommend a mirroring of the California Energy Commission pipeline biomethane verification forms
- Clear consequences must exist for non-compliance with the above data collection requirements
  - These can be related to PBI payments

CUSTOMER LOAD DATA

Why do we need it, how do we use it, and main issues

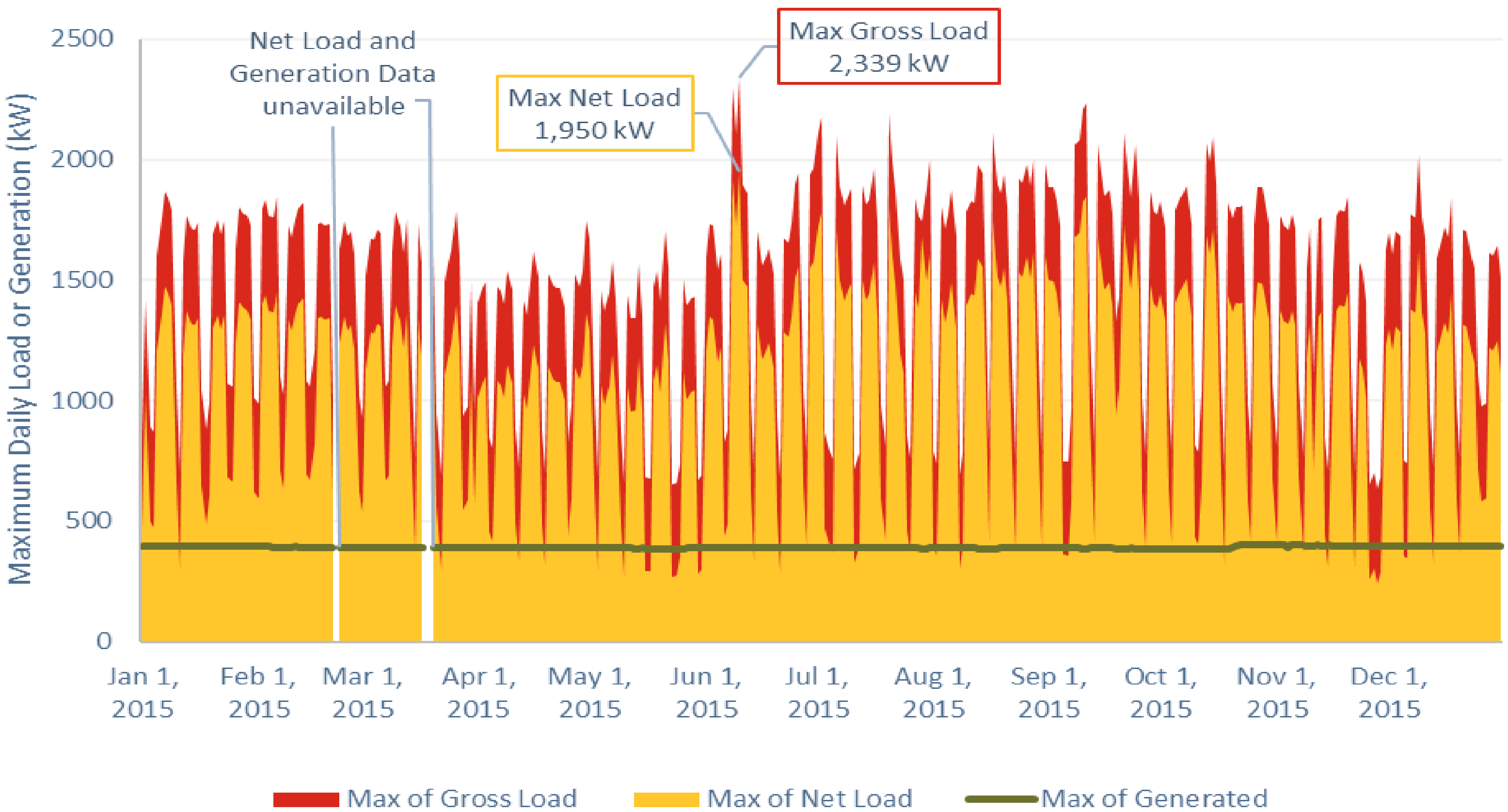
CUSTOMER LOAD DATA

» Why do we need it?
- Understanding customer demand impacts and AES operation
- Quantify the amount of reductions of SGIP aggregate noncoincident customer peak demand required by statute (SB 861)

» How did we use it?
- Match to hourly site level generation or charge/discharge
- Look at how much customer peak was reduced:
  - On an annual basis
  - On a monthly basis and then averaged over the year or season

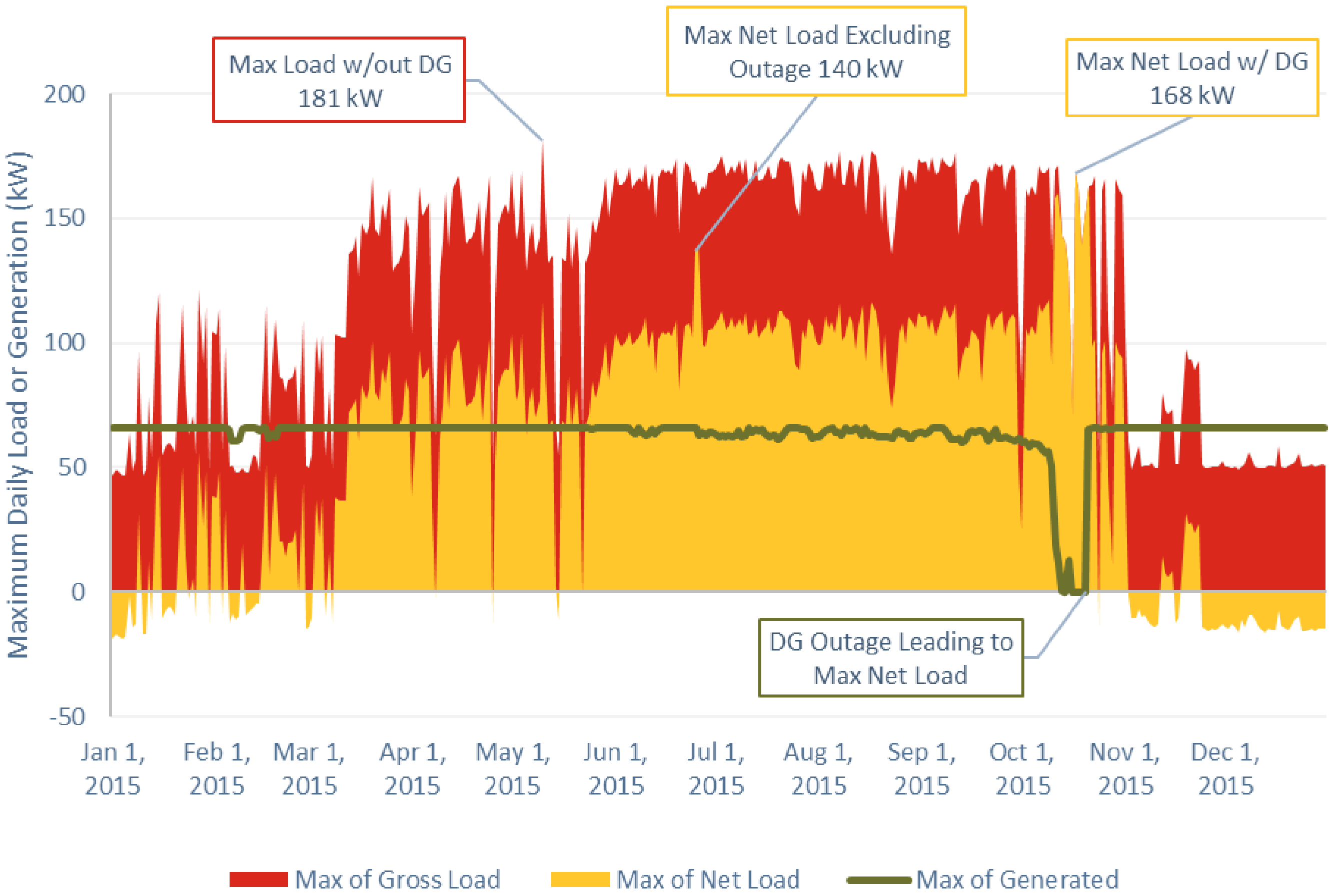
» Issues
- Utilities required NDA's that took significant time
- Couldn't match all projects to load data

CUSTOMER DEMAND IMPACTS



» Consistent operation ->large demand reduction

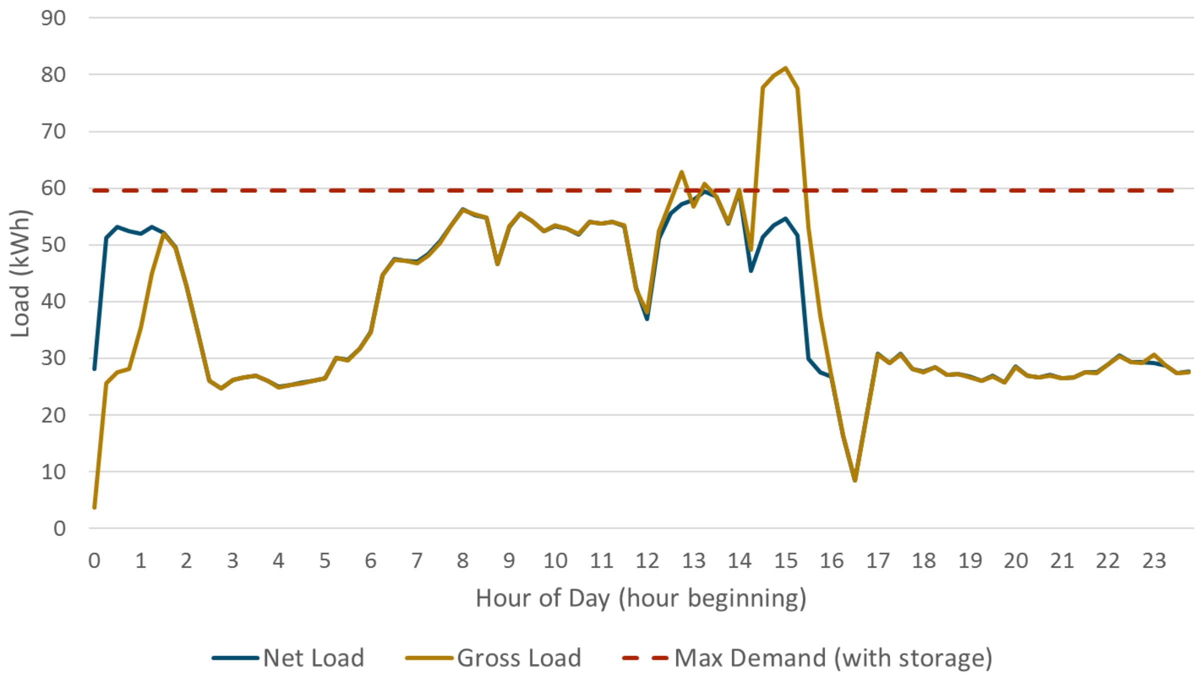
CUSTOMER DEMAND IMPACTS



» Outage yields to minimal annual peak demand reduction

AES CUSTOMER DEMAND IMPACT

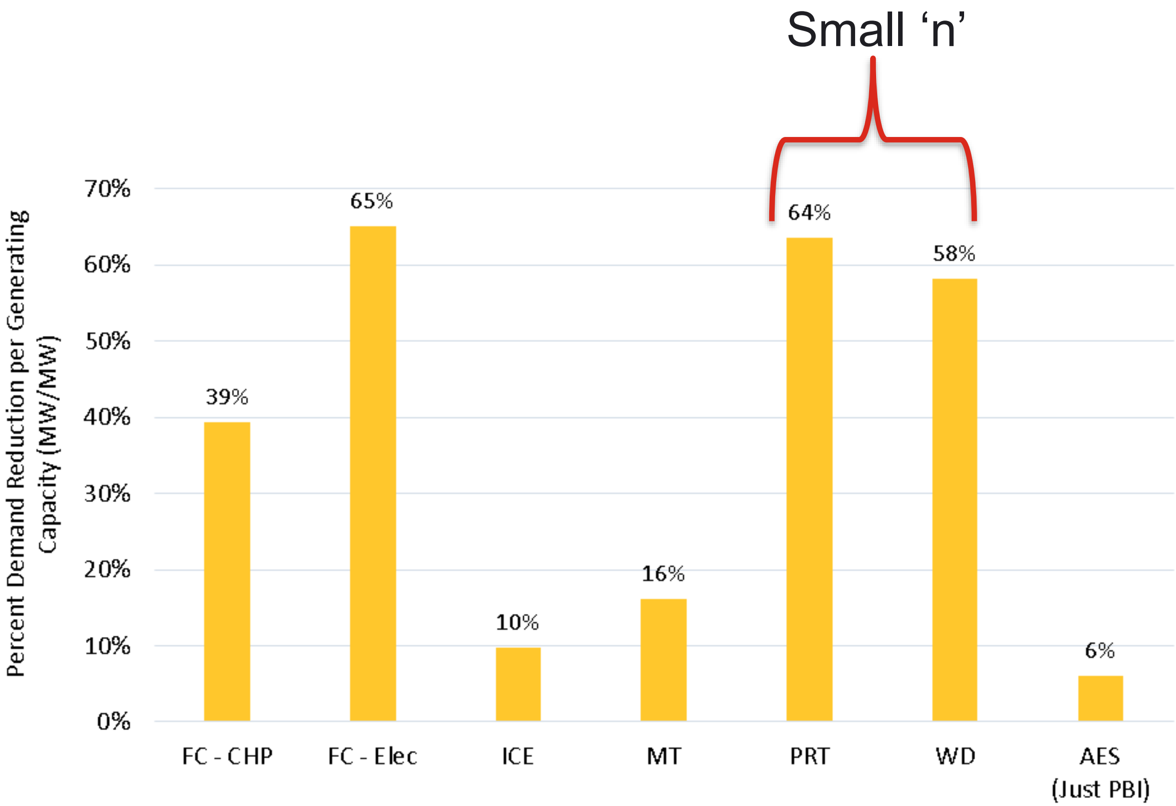
200 kW AES



» Peak reduction but only a fraction of rated capacity

AGGREGATE NONCOINCIDENT CUSTOMER PEAK DEMAND REDUCTION

2015



» All Electric Fuel Cells run almost 24/7/365 so significantly reduce customer peak demand

» AES had surprisingly low impact on customer demand

CLOSING THOUGHTS ON LOAD DATA

- » Need customer load matched to SGIP projects to evaluate non-coincident peak demand impacts as required under SB 861
- » Especially important for AES project where dispatch is likely driven by customer load

ADVANCED ENERGY STORAGE (AES) ANALYSIS

ORIGINAL AES ANALYSIS PLAN

vs. analyses ultimately performed

More data available → Less data available

Data requirements				
Storage charge/ discharge	Utility Load	Site Load	PV Gen.	Metrics generated by E3
✓	✓	✓	✓	• cap factor • Efficiency • Timing of charge & discharge • TOU rate arbitrage • Charging from PV • Demand charge reduction • On-peak energy • Peak demand reduction
✓	✓	est.	✓	
✓	✓	est.	simulate	
✓	✓	-	-	All above except: • Charging from PV PBI analyses
✓	-	-	-	All above except: • Charging from PV • Demand charge reduction Non-res, non-PBI analyses
✓ Data had inaccuracies	-	-	-	• TOU rate arbitrage • Timing of charge & discharge Residential analyses

NON-RESIDENTIAL AES PROJECTS

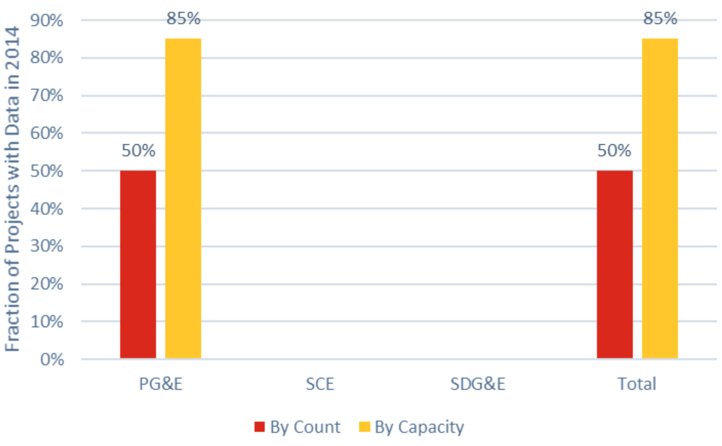
DATA ISSUES

- AES Installer Non-PBI Data
  - Difficult to obtain non-PBI data
    - Many conversations and follow up, delays, pushback, etc.
    - Data ultimately only provided by a handful of operators
  - Could not match individual projects with associated customer load data
    - Data provider provided only anonymized data (identified by sector, IOU, and size)
- Delays in receiving load data
  - Critical for understanding customer demand impacts and AES operation
  - Utilities required NDA's that took significant time

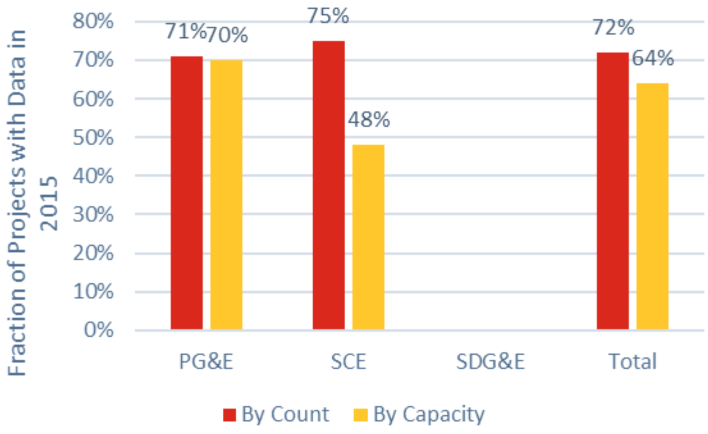
PBI PROJECT DATA (≥ 30KW)

- Sample of 21 projects with charge/discharge data: *72% of PBI projects operating in 2015*
- Able to match 12 projects to IOU load data

Projects operating in 2014:



Projects operating in 2015:

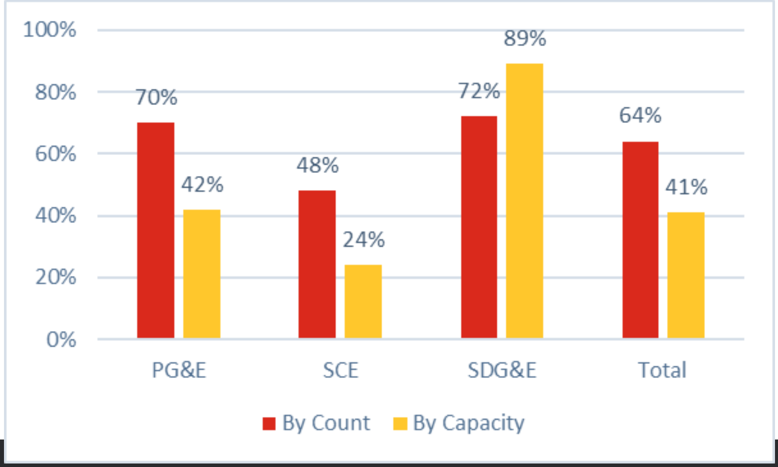


NON-PBI, NON-RESIDENTIAL PROJECT DATA

- Sample of 94 projects with charge/discharge data: *64% of non-PBI, non-res projects operating in 2015*
- Not able to match any projects to IOU Load data
  - Anonymized data → impossible to match to IOU load data

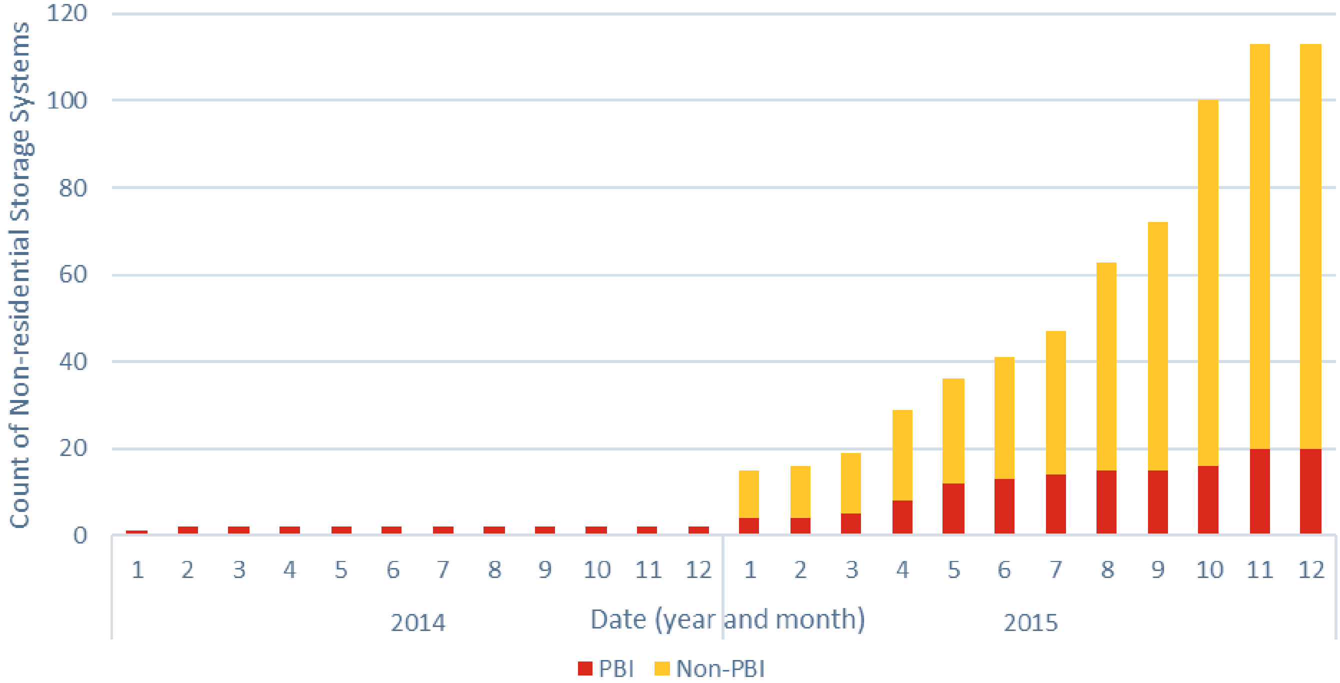
Projects operating in 2014: No data available

Projects operating in 2015:



INSTALLATIONS OVER TIME

Non-residential AES projects



- » Very little 2014 data → Results presented for 2015 only
- » Increasing data availability towards end of year (after Summer peak)

NON-RES ANALYSES

With our data sample, we were able to analyze:

Metric	PBI AES projects	Non-PBI AES projects
Utilization / capacity factors	✓	✓
Round-trip efficiency	✓	✓
Charge/discharge timing	✓ (2015 only)	✓ (2015 only)
Coincident peak impacts	✓ (2015 only)	✓ (2015 only)
CO_2 impacts	✓ (2015 only)	✓ (2015 only)
Charging behavior motivation & Non-Coincident peak impacts	✓ (indicative only: n=5)	✗

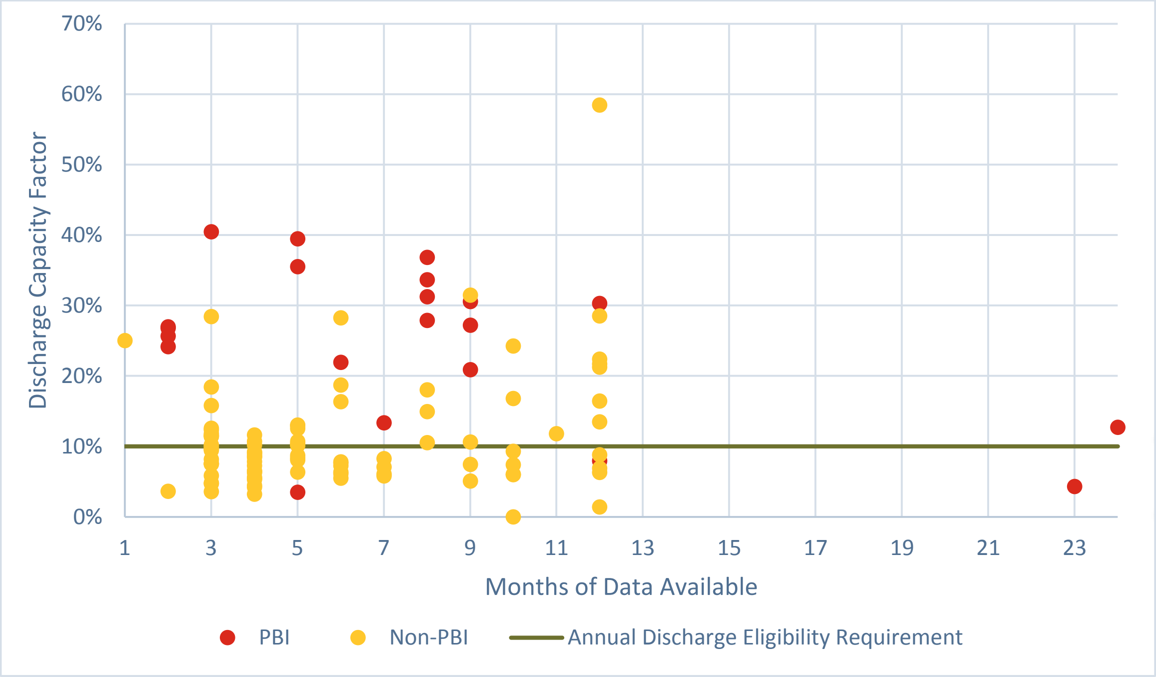
AES UTILIZATION

Non-residential AES projects, 2015

» Storage discharge "capacity factor" defined as:

$$\frac{kWh\ Discharge}{Hours\ of\ Data \times Discharge\ Capacity \times 60\%^{*}}$$

*60% represents the SGIP Handbook assumption of 5,200 discharge hours per yr (5,200 / 8,760 = 60%)



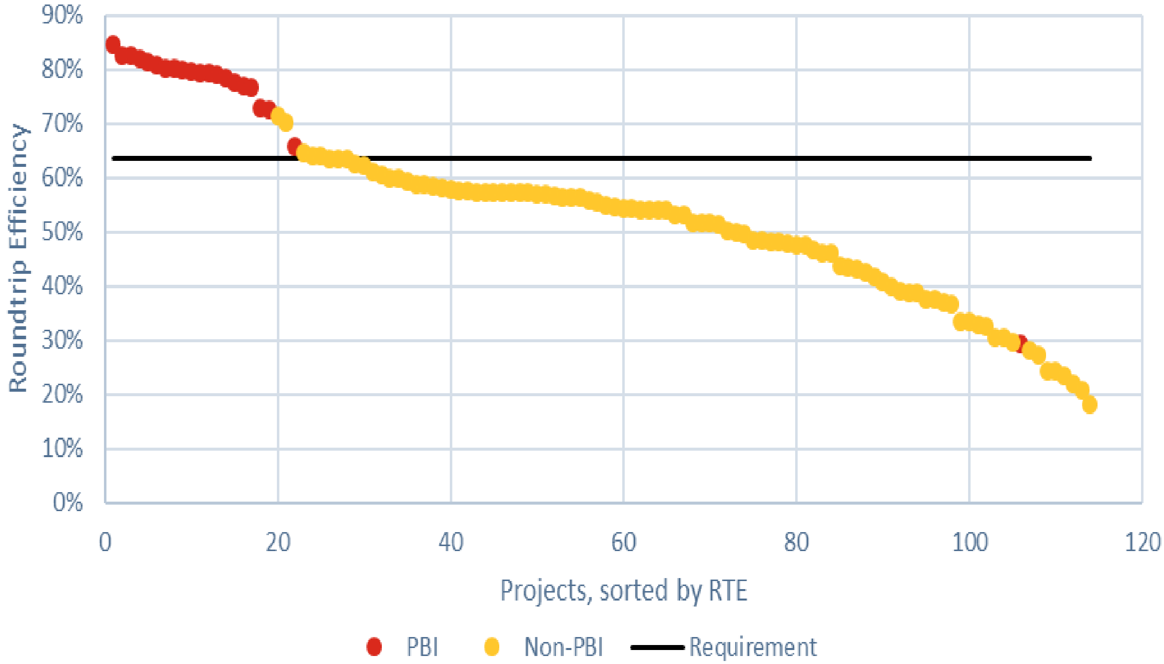
SGIP assumes 520-hr equivalent annual discharge for PBI projects = 10% cap. factor (520 / 5,200 hrs)

- 18 of 21 (86%) PBI projects had capacity factors of at least 10% (required to receive full PBI payment)

ROUNDTRIP EFFICIENCY

» RTE = $\frac{\text{total kWh of discharge from the storage project}}{\text{total kWh of charge}}$

Non-residential AES projects, 2014 - 2015



SGIP PBI requirement, 2014 – 2015: 63.5% annual RTE

» All but one PBI project met the SGIP Handbook requirement of 63.5%

» Only 5% of non-PBI projects had an RTE of 63.5% or more

CHARGE/DISCHARGE TIMING:
PBI PROJECTS CHARGE OVERNIGHT, DISCHARGE IN EVENING

Total kWh of Discharge (Charge) per kW Rebated Capacity, PBI Projects 2015

Hour	Month: 1	2	3	4	5	6	7	8	9	10	11	12
0	-0.05	-0.29	-0.39	-0.54	-0.94	-1.35	-1.43	-1.65	-1.63	-1.49	-1.18	-1.07
1	-0.04	-0.27	-0.31	-0.40	-0.56	-0.91	-0.73	-1.15	-1.14	-1.23	-1.55	-1.18
2	-0.04	-0.26	-0.28	-0.33	-0.19	-0.39	-0.18	-0.66	-0.56	-0.77	-1.27	-1.07
3	-0.04	-0.22	-0.22	-0.30	-0.07	-0.15	-0.11	-0.43	-0.31	-0.57	-0.79	-0.76
4	-0.04	-0.14	-0.19	-0.23	-0.05	-0.09	-0.06	-0.26	-0.16	-0.37	-0.59	-0.56
5	-0.03	-0.08	-0.18	-0.16	-0.03	-0.05	-0.04	-0.18	-0.11	-0.37	-0.45	-0.47
6	-0.02	-0.03	-0.13	-0.11	-0.02	-0.03	-0.02	-0.12	-0.07	-0.27	-0.39	-0.39
7	-0.01	0.00	-0.04	0.01	-0.02	0.00	-0.01	-0.01	-0.03	-0.17	-0.28	-0.31
8	-0.01	0.05	-0.01	0.12	-0.01	0.03	0.00	0.07	0.03	-0.02	-0.12	-0.16
9	0.01	0.07	-0.01	0.03	0.00	0.03	-0.05	-0.01	-0.02	0.08	0.02	-0.01
10	0.00	0.07	-0.01	0.03	0.02	0.06	-0.01	0.07	0.04	-0.02	0.06	0.00
11	-0.01	0.08	0.06	0.09	0.13	0.22	0.03	0.21	0.18	0.16	0.24	0.15
12	-0.01	0.07	0.11	0.09	0.12	0.37	0.08	0.29	0.20	0.23	0.28	0.27
13	0.02	0.07	0.10	0.09	0.14	0.44	0.11	0.26	0.24	0.20	0.28	0.16
14	-0.01	0.09	0.12	0.20	0.36	0.52	0.25	0.39	0.31	-0.17	-0.08	-0.22
15	-0.02	0.10	0.14	0.27	0.62	0.65	0.68	0.82	0.48	-0.17	-0.06	0.07
16	0.04	0.16	0.16	0.23	0.60	0.46	0.63	1.12	0.39	-0.10	0.01	-0.09
17	0.02	0.21	0.24	0.21	0.20	0.12	0.14	0.54	0.17	0.11	0.02	-0.03
18	0.00	0.18	0.24	0.21	0.18	0.17	0.26	0.53	0.88	1.23	0.44	0.28
19	0.01	0.14	0.17	0.12	0.19	0.26	0.48	0.68	1.06	1.51	1.58	1.34
20	-0.01	0.03	0.08	0.03	0.13	0.23	0.38	0.56	0.75	1.42	1.68	1.50
21	-0.01	-0.12	-0.11	-0.16	-0.57	-0.65	-0.72	-1.13	-0.97	-0.64	0.99	1.26
22	-0.05	-0.31	-0.20	-0.17	-0.45	-0.31	-0.08	-0.40	-0.49	-0.10	-0.71	-0.59
23	-0.05	-0.29	-0.30	-0.38	-0.94	-1.01	-0.98	-1.62	-1.31	-1.06	-0.11	-0.20

- Charging overnight, when energy is cheap and emissions are low; discharging in evening, when demand is highest and energy most expensive

CHARGE/DISCHARGE TIMING:

NON-PBI, NON-RES PROJECTS: CHARGING NOT COORDINATED

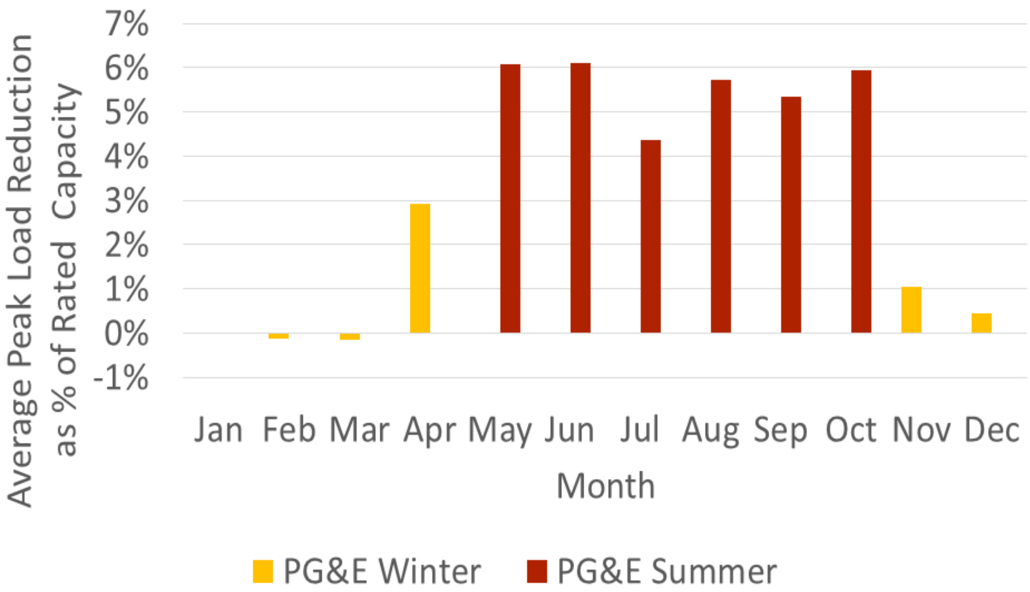
Total kWh of Discharge (Charge) per kW Rebated Capacity, Non-PBI Projects 2015

		Month											
		1	2	3	4	5	6	7	8	9	10	11	12
Hour	0	-0.12	-0.10	-0.11	-0.07	-0.12	-0.14	-0.12	-0.18	-0.10	-0.09	-0.08	-0.08
	1	-0.18	-0.09	-0.14	-0.10	-0.08	-0.08	-0.06	-0.12	-0.07	-0.07	-0.12	-0.15
	2	-0.06	-0.12	-0.10	-0.09	-0.11	-0.05	-0.04	-0.13	-0.06	-0.10	-0.13	-0.18
	3	-0.13	-0.13	-0.10	-0.12	-0.16	-0.03	-0.06	-0.10	-0.05	-0.07	-0.09	-0.14
	4	-0.19	-0.23	-0.05	-0.15	-0.16	0.00	-0.04	-0.05	-0.05	-0.06	-0.09	-0.13
	5	-0.27	-0.15	-0.07	-0.13	-0.10	-0.13	-0.16	-0.20	-0.08	-0.09	-0.12	-0.16
	6	-0.30	-0.04	-0.09	-0.05	-0.12	-0.08	-0.09	-0.14	-0.07	-0.04	-0.10	-0.09
	7	-0.19	-0.06	-0.12	-0.13	-0.15	-0.11	-0.10	-0.15	-0.09	-0.05	-0.12	-0.13
	8	-0.32	-0.18	-0.21	-0.23	-0.25	-0.28	-0.25	-0.23	-0.14	-0.11	-0.11	-0.17
	9	-0.23	-0.28	-0.18	-0.22	-0.19	-0.31	-0.27	-0.24	-0.12	-0.11	-0.14	-0.12
	10	-0.19	-0.23	-0.29	-0.32	-0.23	-0.31	-0.23	-0.31	-0.17	-0.15	-0.06	-0.04
	11	-0.26	-0.17	-0.35	-0.32	-0.37	-0.32	-0.31	-0.36	-0.21	-0.22	-0.04	0.00
	12	-0.21	-0.01	-0.14	-0.07	-0.12	-0.24	-0.20	-0.16	-0.07	-0.02	-0.03	-0.05
	13	-0.33	-0.32	-0.29	-0.29	-0.21	-0.35	-0.26	-0.15	-0.11	-0.06	-0.15	-0.13
	14	-0.20	-0.08	-0.15	-0.06	-0.11	-0.13	-0.12	-0.34	-0.29	-0.30	-0.13	-0.14
	15	-0.22	-0.31	-0.29	-0.27	-0.25	-0.29	-0.28	-0.33	-0.25	-0.28	-0.25	-0.25
	16	-0.16	-0.20	-0.22	-0.24	-0.25	-0.24	-0.19	-0.28	-0.23	-0.26	-0.22	-0.28
	17	-0.10	-0.02	-0.11	-0.11	-0.16	-0.14	-0.11	-0.20	-0.14	-0.18	-0.17	-0.20
	18	-0.17	-0.12	-0.16	-0.17	-0.18	-0.18	-0.19	-0.20	-0.15	-0.18	-0.16	-0.15
	19	-0.18	-0.23	-0.19	-0.24	-0.18	-0.20	-0.17	-0.16	-0.13	-0.16	-0.15	-0.13
	20	-0.15	-0.11	-0.12	-0.16	-0.14	-0.14	-0.15	-0.12	-0.12	-0.13	-0.11	-0.11
	21	-0.15	-0.10	-0.12	-0.14	-0.14	-0.14	-0.12	-0.20	-0.12	-0.12	-0.11	-0.11
	22	-0.15	-0.09	-0.12	-0.12	-0.12	-0.12	-0.12	-0.23	-0.11	-0.11	-0.10	-0.09
	23	-0.15	-0.11	-0.10	-0.11	-0.14	-0.13	-0.13	-0.16	-0.10	-0.08	-0.05	-0.03

- Due to a combination of poor round-trip efficiency and little coordination in charging behavior, almost all month/hours show charging, on average

PBI PROJECTS APPEAR TO BE RESPONDING TO DEMAND CHARGES, BUT SAMPLE IS SMALL

Average Non-coincident Peak Load Reduction by Month per Customer,
n = 5 PBI Projects with a full summer of load and dispatch data available, 2015



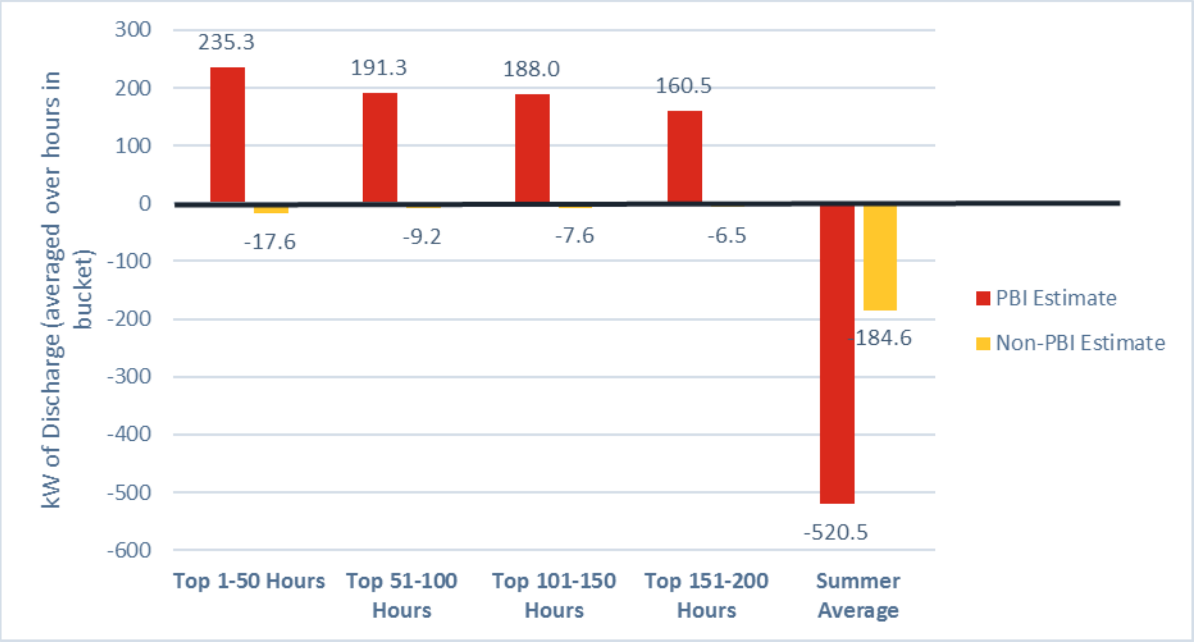
- Significant increase in non-coincident peak load reduction during summer months, compared to the rest of the year
- PBI projects saved an average of ~$0.8 per kW rebated storage capacity in demand charges

    (for n= 9 PBI projects with load and dispatch data available for any months in 2015)

2015 COINCIDENT PEAK IMPACTS

PBI Projects Reduced Peak

Non-PBI Project slightly Increased Peak (due in part to low RTE)

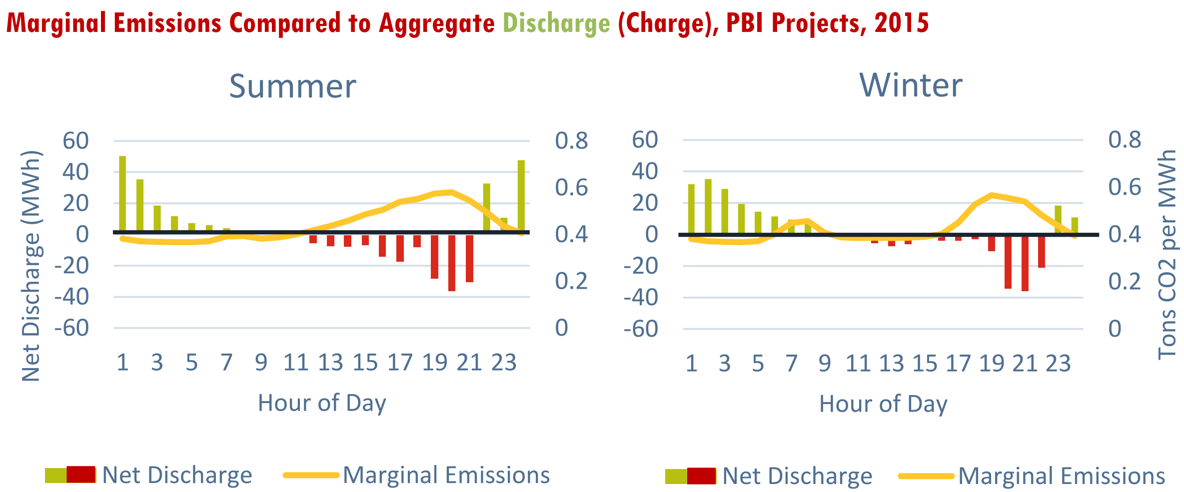


NON-RESIDENTIAL AES CO_2 IMPACTS

Alignment of grid emissions with charge/discharge

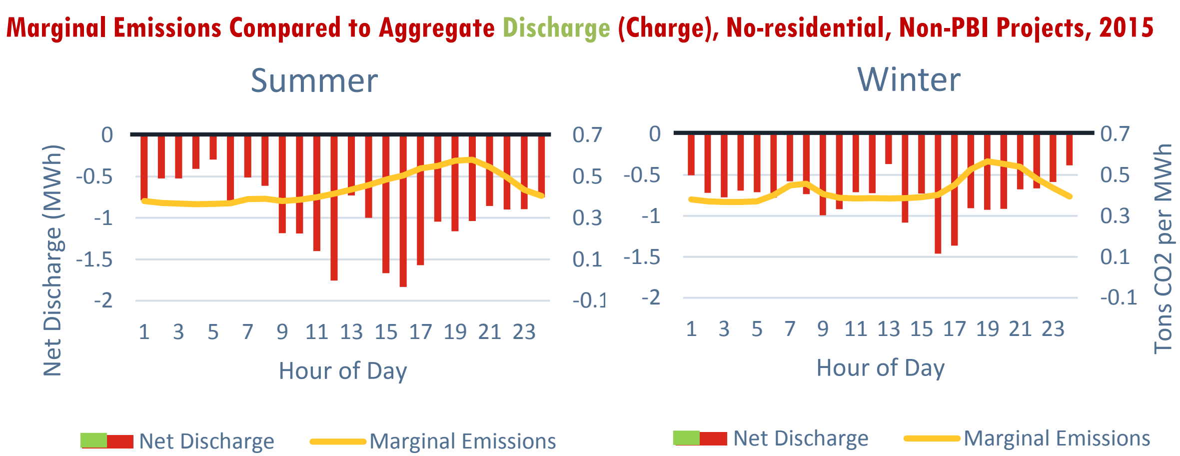
PBI

- Generally discharging during higher marginal emission hours



Non-PBI

- With low efficiency, net charging in all hours

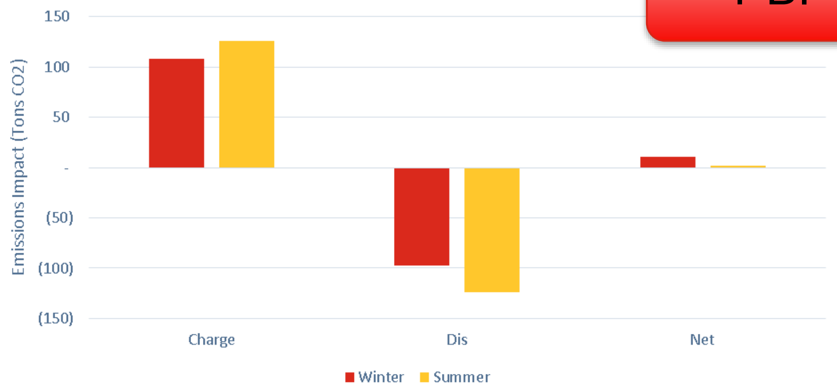


NON-RESIDENTIAL AES CO_2 IMPACTS

Population of estimates

- Net increase in GHG emissions for both PBI and non-PBI systems
- Round trip efficiency losses outweigh GHG savings for PBI systems despite on-peak discharge
- More variable discharge for non-PBI → larger increase in GHG emissions
- Note: these impacts do not include the contribution of storage to integrating renewables

PBI



Non- PBI

RESIDENTIAL AES PROJECTS

RESIDENTIAL AES ANALYSIS CONSTRAINED BY UNRELIABLE DATA

» Difficult to obtain data
  - Many conversations and follow up, delays, pushback, etc.
  - One data provider provided data too late and limited (most just 2016) to be included

» Residential data provided had quality issues
  - Round Trip Efficiencies > 100%
  - Data showed inaccuracies in both the upward and downward direction, depending on data magnitude

» Load Data
  - Utilities required NDA's that took significant time
  - Imperfect match to SGIP projects

RES ANALYSES

With our data sample, we were able to analyze:

Metric	Residential AES projects	Data gaps
Charge/discharge timing	✓ (2015 only)	
Utilization / capacity factors		Accurate magnitude of charge/discharge activity
Round-trip efficiency		
Charging behavior motivation		Accurate measures of both timing and magnitude of charge/discharge activity
Coincident peak impacts		
CO_2 impacts		

RESIDENTIAL PROJECTS APPEAR TO BE CHARGING FROM SOLAR & RESPONDING TO RATES

Total kWh of Discharge (Charge) per kW Rebated Capacity, Residential Projects, 2015

Hour	Month 1	2	3	4	5	6	7	8	9	10	11	12
0	-0.28	-0.25	-0.28	-0.25	-0.26	-0.26	-0.28	-0.29	-0.29	-0.29	-0.24	-0.26
1	-0.28	-0.25	-0.28	-0.25	-0.26	-0.26	-0.29	-0.29	-0.29	-0.29	-0.24	-0.26
2	-0.28	-0.27	-0.28	-0.25	-0.26	-0.26	-0.29	-0.29	-0.29	-0.29	-0.25	-0.26
3	-0.28	-0.25	-0.28	-0.25	-0.26	-0.26	-0.29	-0.30	-0.29	-0.29	-0.25	-0.27
4	-0.29	-0.25	-0.28	-0.25	-0.26	-0.26	-0.29	-0.30	-0.29	-0.29	-0.26	-0.27
5	-0.28	-0.25	-0.28	-0.25	-0.27	-0.27	-0.29	-0.30	-0.29	-0.29	-0.26	-0.27
6	-0.28	-0.25	-0.28	-0.32	-0.50	-0.54	-0.48	-0.37	-0.30	-0.29	-0.26	-0.28
7	-0.28	-0.26	-0.44	-0.78	-1.10	-0.94	-0.97	-0.79	-0.61	-0.44	-0.30	-0.28
8	-0.31	-0.62	-1.47	-2.25	-2.59	-2.20	-2.19	-2.05	-2.00	-1.84	-1.12	-0.50
9	-1.50	-2.17	-3.65	-3.30	-2.73	-3.06	-3.77	-3.91	-3.87	-4.08	-3.42	-1.89
10	-2.90	-2.85	-1.71	-0.64	-0.47	-2.05	-2.95	-2.88	-3.16	-3.47	-5.18	-3.07
11	-1.60	-0.46	-0.31	-0.45	-0.31	-2.14	-3.58	-3.29	-3.42	-2.92	-6.04	-2.36
12	-1.05	-0.33	-0.29	-0.44	-0.35	-2.05	-4.01	-3.53	-3.76	-2.30	-5.95	-2.04
13	-0.72	-0.67	-0.36	-0.24	-0.37	-1.65	-3.81	-3.32	-3.24	-1.10	-3.23	-1.31
14	-0.82	-0.45	-0.56	-0.74	-0.83	-0.88	-1.63	-1.12	-1.22	-0.17	-0.56	-0.89
15	-0.42	-0.44	-0.72	-0.50	-0.40	-0.61	-1.18	-0.56	-0.68	0.17	1.08	-0.55
16	-0.63	-0.55	-0.33	-0.36	-0.50	1.39	4.19	3.46	4.28	1.41	1.80	-0.07
17	-0.47	-0.52	-0.56	-0.55	-0.62	2.01	4.44	3.81	3.78	1.53	2.93	0.25
18	-0.22	-0.30	-0.48	-0.43	-0.50	2.79	4.54	3.56	3.25	1.62	3.30	0.26
19	-0.22	-0.21	-0.27	-0.31	-0.39	-0.47	-0.53	-0.42	-0.19	0.55	2.89	0.24
20	-0.24	-0.23	-0.27	-0.25	-0.26	-0.23	-0.25	-0.25	-0.24	-0.29	2.27	0.24
21	-0.27	-0.25	-0.27	-0.25	-0.26	-0.23	-0.25	-0.27	-0.27	-0.29	-0.23	-0.23
22	-0.28	-0.25	-0.27	-0.25	-0.26	-0.24	-0.27	-0.28	-0.27	-0.29	-0.24	-0.24
23	-0.28	-0.25	-0.27	-0.25	-0.26	-0.25	-0.28	-0.29	-0.28	-0.29	-0.24	-0.25

Box shows hours that correspond with utility's higher TOU rate

Total kWh of Solar Output, Residential Projects, 2015

Hour	Month 1	2	3	4	5	6	7	8	9	10	11	12
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.04	1.37	5.22	1.24	0.04	0.00	0.00	0.00	0.00
6	0.00	0.00	0.72	33.84	132.22	160.17	117.25	45.73	6.02	0.56	0.01	0.00
7	0.43	3.61	89.60	302.35	492.07	402.76	412.66	305.38	198.64	89.79	13.29	1.20
8	70.69	240.20	738.17	1209.20	1426.98	1221.52	1205.92	1113.81	1065.01	960.35	516.22	120.95
9	751.56	1175.95	2077.80	1920.67	1643.83	1847.94	2238.92	2284.08	2249.48	2366.15	1940.27	1003.33
10	1681.15	1725.66	1089.06	502.17	435.73	1317.05	1854.55	1778.56	1934.10	2156.00	3044.13	1750.61
11	1211.06	585.37	431.15	494.85	436.46	1423.47	2274.63	2061.77	2124.16	1936.95	3624.31	1389.51
12	1054.19	545.29	499.39	554.83	508.31	1406.07	2567.07	2226.06	2360.23	1648.94	3687.04	1304.05
13	977.38	704.08	544.40	563.56	604.52	1257.41	2527.71	2148.21	2112.89	1082.45	2411.80	976.69
14	1031.63	629.47	716.49	832.44	918.46	895.37	1362.99	981.09	1061.76	774.02	1316.87	789.36
15	664.60	582.05	780.99	706.62	680.45	740.71	1084.70	643.98	748.22	786.27	736.53	613.50
16	526.38	519.67	478.07	511.51	633.21	795.12	448.78	433.37	374.86	594.82	412.73	351.38
17	247.94	341.06	416.54	451.67	548.50	458.04	405.89	341.22	354.30	356.38	150.26	97.80
18	13.75	111.18	238.62	266.92	336.40	310.78	331.93	285.48	217.36	60.59	0.91	0.25
19	0.00	0.19	18.75	98.44	180.85	246.09	279.27	177.88	23.03	0.02	0.00	0.00
20	0.00	0.00	0.00	0.11	7.08	35.61	30.37	2.88	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

- All residential projects in our sample are paired with solar
- Problems with data integrity → low confidence on discharge magnitudes
- However, by comparing values we do observe that these residential projects charge mid-day (when solar output is highest) and discharge in peak evening hours

AES ANALYSES - 2015

With our data sample, we were able to analyze:

Metric	Non-Res PBI	Non-Res Non-PBI	Res
Utilization / capacity factors	✓	✓	✗
Round-trip efficiency	✓	✓	✗
Charge/discharge timing	✓	✓	✓
Coincident peak impacts	✓	✓	✗
Emission impacts	✓	✓	✗
Motivation & Non-Coincident peak impacts	✓ (indicative only: n=5)	✗	✗
Charging from Solar	✗*	✗*	✗

*Only a fraction of non-res systems were installed at sites with solar

LOOKING FORWARD: OPPORTUNITIES FOR AES

LOOKING FORWARD

- Peak and CO_2 impacts assessed are based on 2015 behavior and system conditions
- System conditions will change over time:
  - CA is on track to increase its renewable generation substantially, which will magnify the potential grid and emission benefits of well-timed storage dispatch.
- As for behavior:
  - Restructured incentives and tariffs, AES projects have the potential to reduce customer peak impacts and carbon dioxide emissions in the future.

RECOMMENDATIONS ON AES

To better capture the value of SGIP AES projects:

1. Ensure better data measurement provision by SGIP recipients
2. Increase storage project RTE requirements and enforcement
3. Improving rate design to better incentivize desired behavior
4. Making sure the party responsible for dispatch receives the appropriate signals to encourage charging and discharging for maximum coincident system peak load and CO_2 reductions
5. Include renewable integration benefits of storage in future impact evaluations

Note: our report expands somewhat on these ideas, but further policy exploration is needed beyond this program evaluation

Questions?

THANK YOU

APPENDIX SLIDES

SCALING SAMPLE TO POPULATION CO_2 & COINCIDENT PEAK IMPACTS

» The AES projects in our sample came "on-line" at various points in 2015

» To scale sample CO_2 and coincident peak impacts to the SGIP AES program population:

1. Calculate % of 2015 for which each project was on-line
2. Multiply this % by the project's nameplate capacity
   → *de-rated capacity* for each project
3. Calculate *de-rate factor* for each project =
   de-rated capacity / nameplate capacity
4. Calculate *average de-rate factor* across the sample
5. Calculate *estimated program-wide de-rated capacity* =
   Average de-rate factor * program-wide nameplate capacity by 2015 year end

SCALING SAMPLE TO POPULATION CO_2 & COINCIDENT PEAK IMPACTS

» **Program-wide CO_2 estimate:**

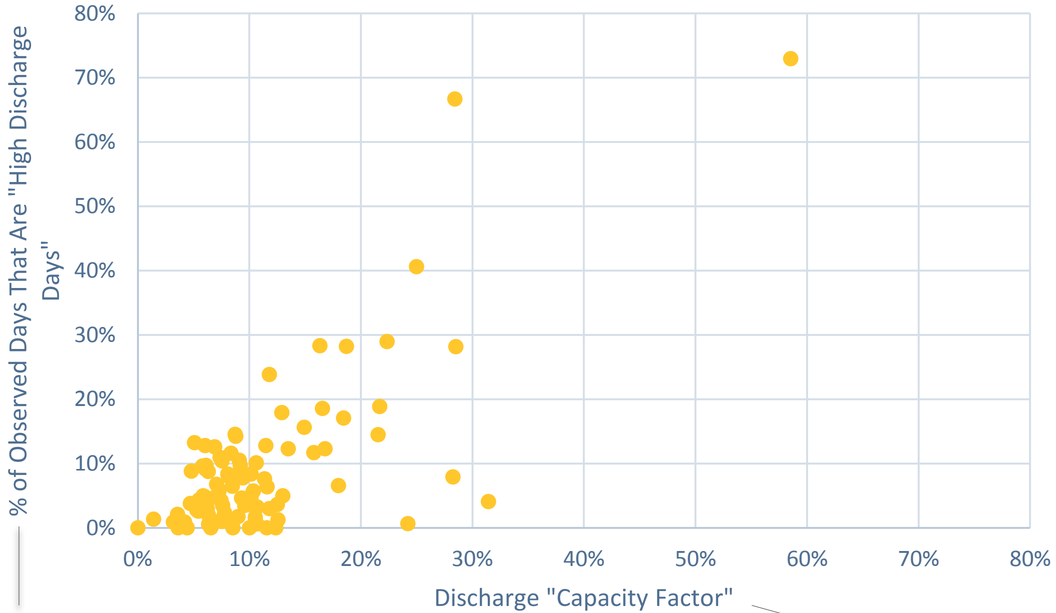
- E3 calculated *tons of CO_2 per kW of de-rated capacity* using each project's net CO_2 emissions and de-rated capacity
- This statistic * program-wide de-rated capacity = program-wide CO_2 emissions

» **Program-wide Coincident Peak estimate:**

- For each peak hour "bucket" (top hour, 2-50, 51-100, 101-150, 151-200), E3 calculated average load contribution for each project
- These averages divided by each project's de-rated capacity → average contribution per kW of de-rated capacity for each bucket
- This statistic was then scaled up by the program-wide de-rated capacity for each bucket

NON-PBI, NON-RES PROJECTS (<30 KW): LOW & INFREQUENT USE, LOW EFFICIENCY

Percent of “High Discharge Days” as a function of Capacity Factor,
Non-PBI Non-Res Projects, 2015



% of days a project was discharged ≥ 20% or more of its rebated capacity

$\frac{\text{actual kWh discharged}}{\text{total possible discharge (5,200 hrs/yr)}}$

- Projects are used infrequently and at low % of their available discharge

E3 MARGINAL EMISSIONS METHODOLOGY

EMISSIONS AS A FUNCTION OF MARKET PRICES

- E3 uses a standard methodology across its public tools (RPS Calculator, Avoided Cost Calculator, etc.) to convert from market energy prices to marginal heat rates in the CAISO
  - Calculated separately for Northern (NP-15) and Southern (SP-15) California
- Methodology assumes that a natural gas-fired power plant is the marginal generator in the CAISO when the day-ahead LMP is above zero
- This marginal heat rate, in Btu/MWh, combined with an emission rate gives a final marginal emission rate in tons CO_2/MWh
  - This analysis assumed a conversion factor of 0.053 metric tons CO_2/MMBtu

CALCULATING MARGINAL HEAT RATE

- For every hour h of the year:

$$Marginal\ Heat\ Rate_{\boldsymbol{h}} = \frac{(Market\ Energy\ Price_{\boldsymbol{h}} - Variable\ O\&M)}{(Wholesale\ Gas\ Price + Delivery\ Adder + Carbon\ Adder)}$$

- Market Energy Prices: Hourly day-ahead market clearing prices in Northern (NP-15) and Southern (SP-15) California
- Variable O&M: Assumed to be $0.68/MWh for the ongoing costs of maintaining the marginal gas generator
- Wholesale Gas Price: 2014 and 2015 daily gas prices from EIA for SoCal Citygate or PG&E Citygate hubs
  - Daily prices are recorded only for weekdays, so weekends are assigned the price of the adjacent weekday

CALCULATING MARGINAL HEAT RATE

- For every hour h of the year:

$$Marginal\ Heat\ Rate_{\boldsymbol{h}} = \frac{(Market\ Energy\ Price_{\boldsymbol{h}} - Variable\ O\&M)}{(Wholesale\ Gas\ Price + Delivery\ Adder + Carbon\ Adder)}$$

- Delivery Adder: Standard value in $/mmBtu associated with delivery of wholesale gas to power plants where it is burned
  - Taken from E3's RPS Calculator
- Carbon Adder: Represents the price of carbon under California Cap and Trade in 2015
  - The value used in this analysis is $12.44/ton
  - Source: 2015 GHG price from the California Energy Commission's 2015 Integrated Energy Policy Report (IEPR)

END-CASE ASSUMPTIONS FOR MARGINAL EMISSIONS METHODOLOGY

- When the day-ahead LMP is at or below zero, MHR is assumed to be zero. This assumption is consistent with renewables being the marginal resource
- When calculated MHR falls between 0 and 6,900 Btu/kWh, MHR is instead assumed to be 6,900 Btu/kWh. This is because the lowest heat rate gas plants in the CAISO are ~6,900 Btu/kWh.
- When calculated MHR is above 12,500 Btu/kWh, MHR is instead assumed to be 12,500 Btu/kWh. This is because the highest heat rate gas plants in the CAISO are ~12,500 Btu/kWh.

EMISSIONS WITH BUILD MARGIN

- Based on approach outlined in D. 15-11-026 which addresses two components of GHG emissions
  - Operating Margin Component
  - Build Margin Component
  - "*SGIP projects have an operating margin effect during the first five years of operations, and a build margin effect thereafter*"
- Operating Margin
  - Operating margin component based on actual 8,760 hourly CO_2 emission rates developed by E3 using market price shapes
- Build Margin
  - The build margin component represents the zero-emission renewables that were not built because of capacity built under the SGIP
    - The build margin is correlated to the RPS
    - Build margin modified is one minus the RPS percentage applicable the year the project was completed
    - Avoided GHG emissions were calculated as shown below:

$$Avoided\ Grid\ GHG_{p,h} = \left(1 - RPSpct_y\right) SGIP\ Generation\ MWh_{p,h} \cdot Marginal\ Emissions\ Rate_h\ \frac{Metric\ Tons}{MWh}$$